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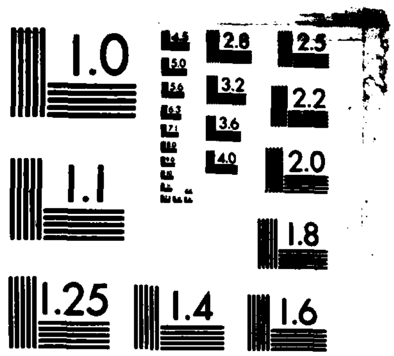
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Special Report 85-7

May 1985

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

An analysis of the Revere, Quincy and Stamford structure data bases for predicting building material distribution

Carolyn J. Merry and Perry J. LaPotin

Prepared for
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Data bases on buildings in Revere and Quincy, Massachusetts, and Stamford, Connecticut, were studied to determine if a measure of building material distribution could be calculated for a city using land use, census tract and the Corps' data on buildings. Statistical measures of chi-square, asymmetric lambda, uncertainty coefficient, F ordinate, as well as the R^2 and η^2 statistics were calculated for the three data bases. The Corps definition of building type was found to be the best predictor of the building surface area.

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20. Abstract (cont'd)

However, all indicators (including building type) explained only low percentages of the variability in the dependent variable (building surface area). Our results indicated that other variables are required to explain the variability of building surface area adequately.

Additional keywords: acid precipitation; acid rain; Tables (data); charts; Army Corps of Engineers;

PREFACE

This report was prepared by Carolyn J. Merry, Geologist, Earth Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory, and Perry J. LaPotin, Research Engineer, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire.

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The authors extend their appreciation to Dr. Harlan L. McKim (CRREL), who was a co-investigator on this project, for his support and helpful technical discussions on the project; to Nancy H. Humiston (CRREL) for data input to the computer; to Richard Ring (New England Division, Corps of Engineers) for his assistance in providing us with the Corps structure inventory data; and to Professors Thomas J. Adler and John P. Wargo (Thayer School of Engineering, Dartmouth College) for their technical reviews of the original manuscript.

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CONVERSION FACTORS: U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

These conversion factors include all the significant digits given in the conversion tables in the ASTM Metric Practice Guide (E 380), which has been approved for use by the Department of Defense. Converted values should be rounded to have the same precision as the original (see E 380).

Multiply	By	To obtain
foot	0.3048*	meter

*Exact

AN ANALYSIS OF THE REVERE, QUINCY AND STAMFORD STRUCTURE DATA BASES FOR PREDICTING BUILDING MATERIAL DISTRIBUTION

Carolyn J. Merry and Perry J. LaPotin

INTRODUCTION

Our work on the acid rain program with the Environmental Protection Agency is in support of Task Group G, Effects on Building Materials and Cultural Resources. One objective is to examine the usefulness of information on land use and census tract for predicting the types and amounts of building materials exposed to acid deposition. To do this we are examining the data bases that the Corps of Engineers District Offices have on file for structures in the flood plains within their jurisdictional boundaries.

We recommended several structure data bases in New England for further study based on the number of land use categories, the types of building material, the structure dimension data, the number of total structures and whether the data base was computerized (Merry et al. 1985). Three New England data bases were selected for this study: Revere and Quincy, Massachusetts, and Stamford, Connecticut (Fig. 1).

The objective of this study was to use the Corps inventories of structures in Revere, Quincy and Stamford to see if land use, census tract and building type information could be used to predict the surface area of each building material type that is exposed. If there is a predictable relationship, a city could be stratified into sampling frames based on land use and census tract information (Rosenfield 1984), and area distributions of building material types could be predicted for other cities with similar demographics.

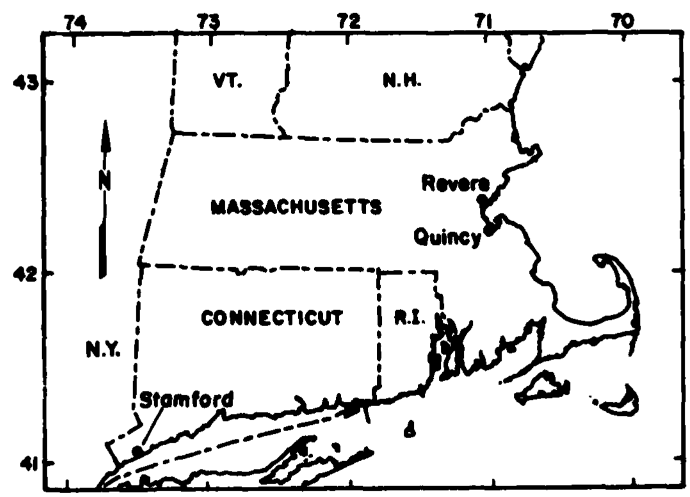


Figure 1. Locations of the three cities studied.

DATA DESCRIPTION

The Corps of Engineers flood plain data for Revere, Quincy and Stamford-comprised five major variables: structure dimension (height, length, width), structure type and structure material. Both census tract and land use information by location were added to the original Corps of Engineers data.

Dimension variables were calculated from the Corps data on structure length, width and number of stories. The height of each structure was estimated by multiplying the number of stories per structure by our estimate of the average height per story (12 ft).

Each structure was categorized according to the primary use of the building. The ranking from 1 to 3 was made according to the degree of urbanization:

Code	Building type
1	single-family residential
2	multi-family residential
3	commercial/industrial.

Building material types were coded from 1 to 8 according to the predominant material within a given structure. The categories were:

Code	Predominant Material
1	Wood
2	Brick
3	Stucco
4	Cement/concrete
5	Metal (ferrous, non-ferrous)
6	Shingles (asphalt)
7	Stone
8	Vinyl.

Land use data (1:250,000 scale) were based on the digital information from GIRAS (geographic information retrieval and analysis system) (Mitchell et al. 1977). The aerial photographs used in GIRAS are from 1972-1974 (Loelkes 1977). The following categories of land use were found in the Stamford, Quincy and Revere data bases:

Code	Class	Description
11	Residential	Single family dwellings, multiple-unit structures
12	Commercial and services	Stores, shopping centers
13	Industrial	Light to heavy manufacturing
17	Other urban or built-up land	Urban parks, cemeteries, undeveloped land within an urban setting
51	Streams and canals	Rivers, creeks and canals
62	Nonforested wetlands	Marshland, wet meadows and bogs.

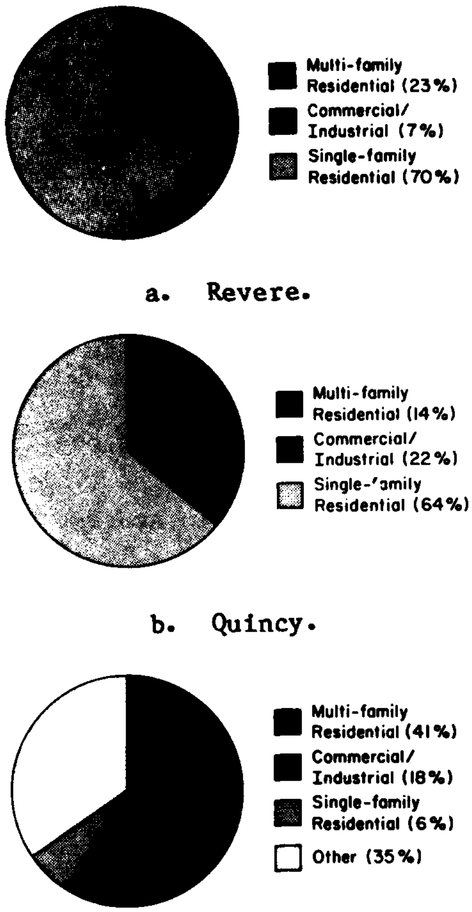
Additional description of the land cover classes can be found in Anderson et al. (1976).

The census tract numbers that were found in the data sets of Stamford, Quincy and Revere are:

Location	Census Tract
Stamford	201, 213, 215, 216
Quincy	4177, 4179, 4180, 4191
Revere	1704, 1705, 1706.

Figure 2 shows the relative distribution of building types in Revere, Quincy and Stamford. The Stamford buildings are primarily multi-family residences (41%), followed by industrial/commercial structures (18%). Only 6% of the sampled Stamford buildings are single-family residences. A significant portion of the Stamford data (35%) was not classified by building type and therefore is shown by missing values. In both Quincy and Revere, single-family residences dominate the classification, representing, respectively, 64% and 70% of the sites examined. A smaller percentage of multi-family residential structures was found, with 14% observed in Quincy and 23% found in Revere. The Quincy site showed the largest proportion of commercial/ industrial buildings (22%), followed by Stamford (18%) and Revere (7%).

Figure 3 illustrates the relative proportion of land use within each city. Residential land use dominates in Stamford and Quincy (85% and 75%, respectively). Nonforested wetlands is the most prevalent category in Revere (59%). The commercial and services category is well represented in Stamford (11%) and Quincy (23%) but not in Revere (6%). This distribution

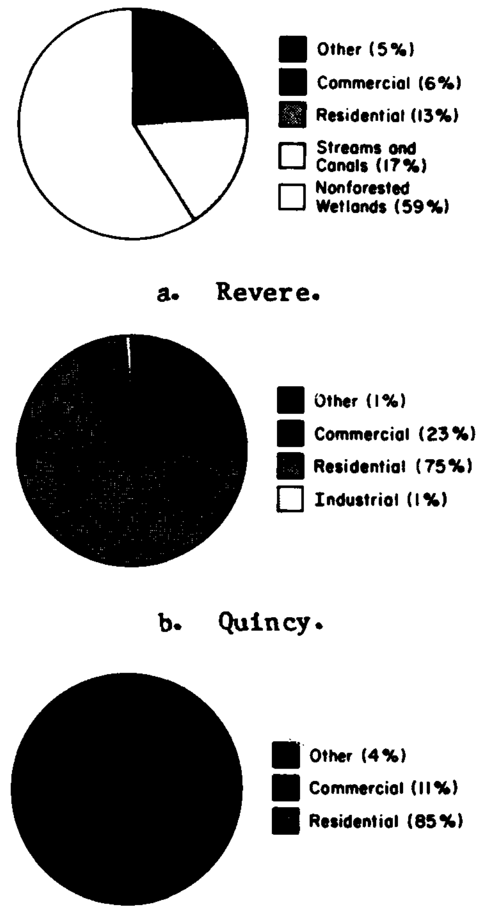


a. Revere.

b. Quincy.

c. Stamford.

Figure 2. Frequency distribution of building type.



a. Revere.

b. Quincy.

c. Stamford.

Figure 3. Frequency distribution of land use.

suggests that rural land groupings are less frequent in both Stamford and Quincy and more frequent in Revere. If streams, canals and nonforested wetlands are considered rural, less than 1% of the land in Stamford and Quincy is rural, while 76% of Revere is classified as rural. All three locations have a low percentage of industrial land use (less than 1%), the classification that traditionally has the largest building material exposure (EPA 1983).

Figure 4 illustrates the distribution of buildings in each census tract. Most of the Revere buildings are within census tract 1705 (69%), with only 26% in the combined tracts of 1704 and 1706. In Quincy, 80% of the buildings are within census tracts 4191 (45%) and 4180 (35%). The Stamford data are split between three major census tracts.

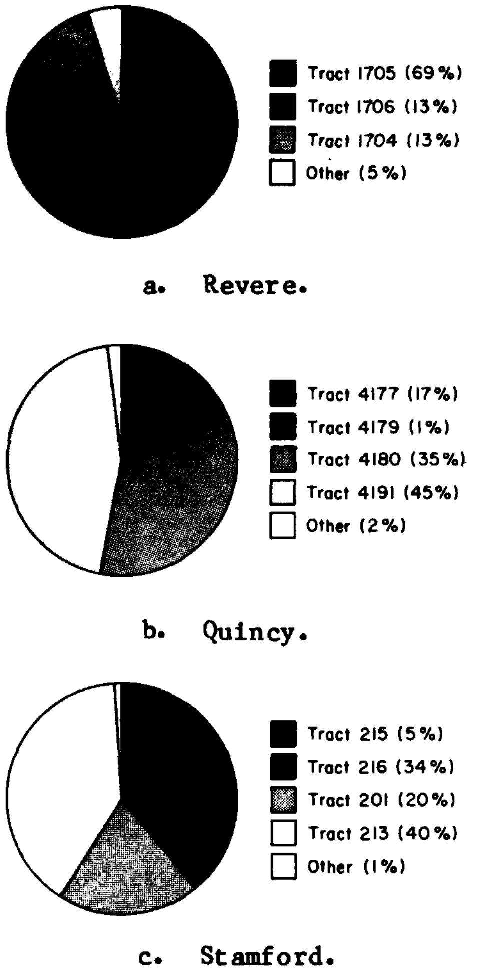


Figure 4. Frequency distribution of census tract.

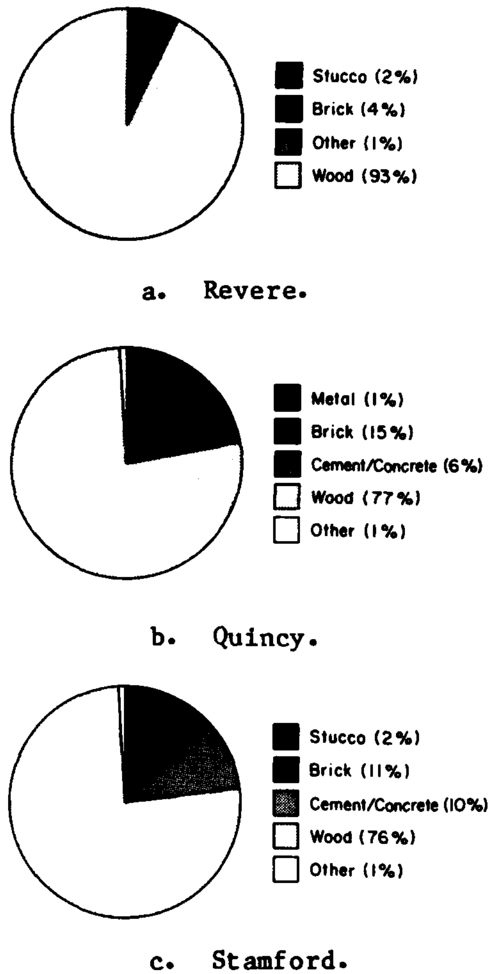


Figure 5. Frequency distribution of building material type.

The Corps of Engineers classifies structures in the flood plain according to the predominant material in the total building. In this form of classification, predominant materials are over-represented (100%) and subordinate materials are under-represented (0%). The loss of information becomes significant when structures with roughly even proportions of material type become classified as a single material type (for example, a building made of 51% brick and 49% wood is classified as 100% brick and 0% wood). This condition will generally result in random errors, which simply increase uncertainty but do not bias statistical parameter estimates. The bias will be worse if one material type is frequently minor and rarely predominant.

It is not surprising, then, that one or two materials might dominate the entire classification of building material type. The distribution of material types is provided in Figure 5. In all three locations, wood construction dominates (Revere 93%, Quincy 77% and Stamford 76%). This class in-

cludes both painted and unpainted wood surfaces, as well as stained wood exteriors. In Revere, only 7% of the buildings (neglecting missing values) have non-wood surfaces. In Stamford, non-wood surfaces contributed less than one quarter of the sampling points. The Quincy distribution is principally wood (77%), followed by brick (15%) and cement/concrete (6%).

DATA ANALYSIS

Discrete variables

The Statistical Package for the Social Sciences (SPSS) software was used in our statistical analyses (Nie et al. 1975). We analyzed the three data bases on buildings in two ways. First, we divided the building surface area data into discrete variables by grouping the data points into five groups. By analyzing the data this way, chi-square, asymmetric lambda and the uncertainty coefficient could be obtained. The second part of our analysis treated the building surface area as a continuous variable, rather than a discrete variable. This was done in case we had made an incorrect assumption when dividing the building surface area into discrete variables.

We used contingency tables to determine how much the building surface area and the type of material depend on building type, census tract and land use (Appendix A). The building surface area, a continuous variable, was divided into five classifications, with each classification containing approximately 20% of the total data points for each city. The segmentation routine was

$$\text{if} \quad P_i \leq P < P_{i+1} \quad \text{then } Pg = i+1$$

$$\text{where} \quad P_g = \int_{P_i}^{P_{i+1}} f(p)dp = 0.20$$

$$i = 0, 1, 2, .. m$$

where i = group number index for building surface area

m = number of groups (equal to 5 in our analysis)

Table 1. Statistical measures of chi-square, asymmetric lambda and the uncertainty coefficient of building surface area and building material with building type, building material, census tract and land use for Revere, Quincy and Stamford.

			Independent variables				
			Building type	Building material	Census tract	Land use	
Dependent variables	Building surface area	Significance of χ^2	< 0.0001	< 0.0001	0.0003	< 0.0001	Revere
			< 0.0001	< 0.0001	< 0.0001	< 0.0001	Quincy
			< 0.0001	< 0.0001	< 0.0001	0.0001	Stamford
		λ (asymmetric)	0.19368	0.04560	0.00760	0.03800	Revere
			0.15745	0.13191	0.20435	0.12446	Quincy
			0.18675	0.19844	0.12941	0.03704	Stamford
		Uncertainty coefficient (asymmetric)	0.14603	0.03329	0.00799	0.01386	Revere
			0.11867	0.08217	0.17909	0.09518	Quincy
			0.09648	0.12664	0.08363	0.02209	Stamford
	Building material	Significance of χ^2	< 0.0001		0.0095	0.0329	Revere
			< 0.0001		< 0.0001	< 0.0001	Quincy
			< 0.0001		< 0.0001	< 0.0001	Stamford
		λ (asymmetric)	0.00000		0.00000	0.00000	Revere
			0.43478		0.04688	0.00000	Quincy
			0.34884		0.02326	0.00000	Stamford
		Uncertainty coefficient (asymmetric)	0.10387		0.05716	0.05338	Revere
			0.50547		0.26643	0.15918	Quincy
			0.33845		0.22137	0.08327	Stamford

P_i = index on the building surface area distribution

P_g = building surface area group

$f(p)$ = distribution of building surface areas by location

P = exposed building surface area.

The new variable, P_g, contains 20% of the data points from the distribution of building surface area, P.

A matrix of association between the dependent variables (building surface area and building material) and the independent classification variables (building type, census tract and land use) is presented in Table 1. Cross-tabulations for each pair summarized in Table 1 are provided in Appendix A. Building material is included as both an independent and a dependent variable. This was done to examine the level of association between building surface area and material type (for example, if the building material is known, how much information about the building surface area

follows). Each cell in the matrix has three values corresponding to the sampling location.

Two measures of explaining power, the asymmetric lambda (λ) coefficient and the uncertainty coefficient (asymmetric), were computed. The asymmetric lambda statistic measures the improvement in predictive power as a result of the additional information obtained by the independent variable. "The maximum value of lambda is 1.0, which occurs when a prediction can be made without error, i.e., when each independent variable category can be associated with a single category on the dependent variable. A value of zero means no improvement in prediction" (Nie et al. 1975, p. 225). As an example of its use, consider the lambda value of 0.19 for building type and building surface area for the Revere data (Table 1). This value suggests that knowing the building type (for example, single-family residence) increases one's ability to predict the value of building surface area by 19%.

The uncertainty coefficient is a measure of uncertainty reduction in the dependent variable as a result of knowledge about the behavior of the independent variable. "The maximum value for the uncertainty coefficient is 1.0, which denotes the complete elimination of uncertainty. As with lambda, this is achieved only when each category of the independent variable is associated with a single category on the dependent variable. When no improvement occurs, the uncertainty coefficient takes on the value of zero" (Nie et al. 1975, pp. 226-227). For the example of building surface area and building type in Revere, the uncertainty coefficient was 0.15. This value suggests that one is 15% more certain of the behavior of building surface area as a result of knowing the building type.

The chi-square statistic was computed for each dependent-independent variable pair. The significance level in the chi-square test may be interpreted as the probability of getting a chi-square ordinate of the value observed (or one greater) given the null hypothesis (i.e. that statistical independence is true). Thus, small probabilities suggest a small likelihood of independence and larger probabilities (0.10 and above) imply a strong potential for statistical association. This statistic is used to determine whether or not there is a systematic relationship between two variables (the test of statistical independence). The chi-square values for the relationships between building surface area and each classification variable (building type, building material, census tract and land use) are significant at the 0.0001 level or below except for the value for building surface area and

census tract for Revere, which was significant to the 0.0003 level. In each case, we can suggest a rejection of the null hypothesis that the variables are statistically independent (Walpole and Myers 1978). This does not imply a cause-and-effect relationship between the variables; it simply implies that there is a systematic relationship between building surface area and building type, building material, census tract and land use.

The asymmetric lambda and the uncertainty coefficient provide associated measures of explaining power between the variables listed in the matrix. These measures improve on the chi-square statistic by providing indicators of dependency, not just addressing the question of statistical independence.

For the Revere, Quincy and Stamford data bases, each of the variables is a fairly poor predictor of the building surface area and the building material type. The highest asymmetric lambda value is approximately 0.19 for predicting the building surface area knowing building type. Values are lower, however, for the corresponding uncertainty coefficients. For Stamford, information on building type improves our understanding of the building surface area distribution only slightly, with an uncertainty coefficient of 0.10. For Quincy and Stamford the building type is the strongest predictor of building material type, with uncertainty coefficients of 0.50 and 0.34,but the relationship does not hold for Revere, with an uncertainty coefficient of 0.10.

It has been postulated that building materials provide information about the size of the structure and thus the building surface area (EPA 1983). For example, reinforced concrete is normally found in larger buildings requiring additional structural integrity. However, for the three sites we considered, knowledge of the material type improves our prediction of building surface area only slightly. This follows from the lack of diversity of materials at each location (Fig. 5) and perhaps from the method with which structures were classified (i.e. according to the predominant material only).

Classification of building surface areas and material types by census tract produced significant chi-square ordinates. In all cases the independence of building surface area and building material with census tract was rejected at the 0.01 level and below. The lambda and uncertainty coefficients for Revere show that census tract is not helpful in predicting building surface area and building material. The uncertainty coefficient shows that knowing the census tract provides only a 0.8% decline in uncertainty about building surface area and material type.

In Quincy, knowledge of the census tract reduces the uncertainty of building material distribution by 27%. The lambda values suggest that the power of census tract for predicting building material type is close to 5%. An 18% reduction in uncertainty of building surface area distribution results from knowledge of census tract. In addition the census variable provides 20% of the information about building surface area.

For Stamford, census tract information produced a 13% improvement in predicting building surface area. The use of census tract as an indicator for building material type is far less significant, yielding a 2% rise in explaining power. The corresponding loss of uncertainty was significant at 22%.

The final variable considered in Table 1 is land use. The chi-square values show that a relationship exists between land use and building surface area. Lambda values for Revere show that land use outperforms census tract as a predictor of building surface area. In Quincy and Stamford, census tract is a much better predictor of building surface area. In Quincy, there was approximately a 18% rise, and in Stamford, an 8% rise. Land use classification is a very poor predictor of material type in all three locations (lambda values below 0.0001).

Continuous variables

The analysis comparing building surface area as a continuous variable with building type, building material, land use and census tract for the three cities is presented in Table 2. Three measures of explaining power indicate the relative importance of the independent variables for predicting building surface area.

The one-way analysis of variance allows us to statistically test whether the means of subgroups into which our sample data are broken are significantly different from each other. We are testing the null hypothesis that the subgroup means are equal. If the means are not found to be significantly different, we cannot reject the null hypothesis, and we must assume that the deviations that occur are the result of sampling error. Conversely, if the means are significantly different, we cannot accept the the null hypothesis. The actual test compares the computed F ratio to the known sampling distribution of the F ratio, given the null hypothesis.

The first measure in Table 2, the significance of F, displays the probability value for an F test. Significance values listed correspond to the probability of obtaining an F value of that size or larger, given the null

Table 2. The continuous form of building surface area (dependent variable) on the independent variables of building type, building material, land use and census tract for Revere, Quincy and Stamford.

			Independent variables				
			Building type	Building material	Land use	Census tract	
		Significance of F	< 0.0001	< 0.0001	0.6813	0.2088	Revere
			< 0.0001	0.0001	< 0.0001	0.0251	Quincy
			0.0039	< 0.0001	0.0012	0.4307	Stamford
Dependent Variable	Building surface area	R^2	0.2808	0.0949	0.0005	0.0005	Revere
			0.0860	0.0445	0.0575	0.0298	Quincy
			0.0353	0.0385	-	0.0001	Stamford
		η^2	0.5127	0.1354	0.0019	0.0026	Revere
			0.0991	0.0860	0.0721	0.0318	Quincy
			0.0462	0.1180	0.0296	0.0077	Stamford

hypothesis of equality of means (Walpole and Myers 1978). By separating building surface area by building type (single-family residences, multifamily residences and commercial/industrial buildings), it is evident that the building type classification is an important grouping variate (probability values of 0.0039 in Stamford and <0.0001 in Revere and Quincy). Building material is also an important classification variable in all three locations. In Revere, grouping by land use explains little about building surface area, perhaps because of the large proportion of the Revere structures that are located in nonforested wetlands (59%). Census tract categorization is only marginally useful in Revere and Stamford. In Quincy, however, the F significance (0.0251) suggests census tract information to be more useful in categorizing building surface area.

The multiple correlation coefficient (Pearson R^2) measures the proportion of variance of the dependent variable (building surface area) explained by the independent variables (building type, building material, landuse or census tract) when a standard linear regression model is applied to the data. The Pearson R^2 is a measure of the goodness of fit of the regression line to the data. The eta-squared (η^2) statistic measures the same proportion but includes higher-order nonlinear terms (about the population means). These measures show that building type explains 28% of the linear variability of building surface area and 51% of the linear plus nonlinear variability in Revere. The building type classification explains minor pro-

portions in both Quincy and Stamford. Building material and land use explain only a small amount of the variability in building surface area. In addition, knowledge of census tract information appears to be of little help in predicting the building surface area.

SUMMARY AND CONCLUSIONS

Data bases on structures in Revere and Quincy, Massachusetts, and Stamford, Connecticut, were studied to determine if a measure of building material distribution could be calculated for a city using land use, census tract and building type information. Significance measures of chi-square, asymmetric lambda, uncertainty coefficient, F ordinate, as well as the R^2 and η^2 statistics were calculated for the three data bases. The Corps definition of building type was found to be the best (largest R^2 and η^2) predictor of the building surface area. However, all indicators (including building type) explained only low percentages of the variability in the dependent variable.

The chi-square statistic showed that a systematic relationship existed between building surface area and building type, building material, census tract and land use. A systematic relationship also existed between building material type and building type, census tract and land use.

The asymmetric lambda statistic indicated that the variables were fairly poor predictors of building surface area and building material type. The most consistent variable was building type at a value of 0.19 for predicting the building surface area. Building type was also the best predictor of building materials for Quincy and Stamford, but this relationship did not hold for Revere. Knowledge of land use did not improve predictions of building material type.

The uncertainty coefficient showed that knowledge of the independent variables did not reduce the uncertainty about the two dependent variables of building surface area or building material. The highest value was 0.50 for building type for Quincy, but the values for the other two data sets were low.

The F statistic is used to statistically test whether the means of subsamples in which the data are broken significantly differ from each other. The F values were large for the building type and building material variables, so we rejected the null hypothesis that the means are equal. However, for the land use and census tract variables in Revere the F-values were low,

so we cannot reject the null hypothesis that the means are equal; however, this did not hold for the Quincy and Stamford data sets for land use. As a result the variables of land use and census tract may not be useful for estimating the building surface area.

The R^2 statistic measures the proportion of variance in the dependent variable, building surface area, that is linearly explained by the independent variables of building type, building material, land use or census tract. In all cases the R^2 value is low, so the proportion of variance in the building surface area cannot be linearly explained by any of the independent variables. The largest R^2 was for building type, but this was still too low to be of any value.

The η^2 statistic measures the total (linear and nonlinear) variance that is explained by the independent variables of building type, building material, land use and census tract. In all cases the η^2 statistic was low, with the highest value for building type for the Revere data set. This tentatively confirms that the Corps definition of building type is the best independent variable to use for predicting building surface area.

In summary, this study examined the use of three readily available classification variables (census tract, land use and building type) for predicting the exposed surface area of various building materials. Our results indicated that other variables are required to adequately explain the variability of building surface area.

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APPENDIX A: Cross tabulations of building surface area by building type, land use, census tract and building material, and material type by building type, land use and census tract.

Table A1. Cross tabulation of building surface area by building type for Revere.

Surface area (sq ft)	COUNT / ROW PCT / COL PCT / TOT PCT	TYPE 1.00	2.00	3.00	ROW TOTAL
P < 1250	COUNT	253	0	0	253
	ROW PCT	100.0	0.0	0.0	20.2
	COL PCT	28.9	0.0	0.0	
	TOT PCT	20.2	0.0	0.0	
1250 ≤ P < 1950	COUNT	242	30	0	272
	ROW PCT	89.0	11.0	0.0	21.7
	COL PCT	27.7	10.3	0.0	
	TOT PCT	19.3	2.4	0.0	
1950 ≤ P < 2250	COUNT	159	71	0	230
	ROW PCT	69.1	30.9	0.0	18.4
	COL PCT	18.2	24.5	0.0	
	TOT PCT	12.7	5.7	0.0	
2250 ≤ P < 2750	COUNT	130	120	0	250
	ROW PCT	52.0	48.0	0.0	20.0
	COL PCT	14.9	41.4	0.0	
	TOT PCT	10.4	9.6	0.0	
2750 ≤ P	COUNT	90	69	89	248
	ROW PCT	36.3	27.8	35.9	19.8
	COL PCT	10.3	23.8	100.0	
	TOT PCT	7.2	5.5	7.1	
COLUMN TOTAL		874	290	89	1253
		69.8	23.1	7.1	100.0

Chi square = 610.18396 with 8 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.00000 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.30190 with TYPE dependent

Pearson's R = 0.54634; Significance = 0.00000

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A2. Cross tabulation of building surface area by land use for Revere.

Surface area (sq ft)	LU: COUNT / ROW PCT / COL PCT / TOT PCT	11.00	12.00	17.00	51.00	62.00	ROW TOTAL
P < 1250	COUNT	18	29	0	54	152	253
	ROW PCT	7.1	11.5	0.0	21.3	60.1	21.2
	COL PCT	10.7	36.7	0.0	26.0	20.6	
	TOT PCT	1.5	2.4	0.0	4.5	12.7	
1250 ≤ P < 1950	COUNT	41	17	0	40	174	272
	ROW PCT	15.1	6.3	0.0	14.7	64.0	22.8
	COL PCT	24.4	21.5	0.0	19.2	23.6	
	TOT PCT	3.4	1.4	0.0	3.4	14.6	
1950 ≤ P < 2250	COUNT	23	11	1	36	159	230
	ROW PCT	10.0	4.8	0.4	15.7	69.1	19.3
	COL PCT	13.7	13.9	100.0	17.3	21.6	
	TOT PCT	1.9	0.9	0.1	3.0	13.3	
2250 ≤ P < 2750	COUNT	49	15	0	33	153	250
	ROW PCT	19.6	6.0	0.0	13.2	61.2	21.0
	COL PCT	29.2	19.0	0.0	15.9	20.8	
	TOT PCT	4.1	1.3	0.0	2.8	12.8	
2750 ≤ P	COUNT	37	7	0	45	99	188
	ROW PCT	19.7	3.7	0.0	23.9	52.7	15.8
	COL PCT	22.0	8.9	0.0	21.6	13.4	
	TOT PCT	3.1	0.6	0.0	3.8	8.3	
COLUMN TOTAL		168	79	1	208	737	1193
		14.1	6.6	0.1	17.4	61.8	100.0

Chi square = 53.93908 with 16 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.00000 with LU dependent

Uncertainty coefficient (asymmetric) = 0.02086 with LU dependent

Pearson's R = -0.05059; Significance = 0.0403

Land use (LU) key:
- 11 = Residential
- 12 = Commercial and services
- 17 = Other urban or built-up land
- 51 = Streams and canals
- 62 = Non-forested wetlands

Table A3. Cross tabulation of building surface area of census tract for Revere.

Surface area (sq ft)	CENS COUNT ROW PCT COL PCT TOT PCT	1704.00	1705.00	1706.00	ROW TOTAL
P < 1250		21 8.3 12.7 1.8	191 75.5 22.1 16.0	41 16.2 25.0 3.4	253 21.2
1250 ≤ P < 1950		47 17.3 28.3 3.9	185 68.0 21.4 15.5	40 14.7 24.4 3.4	272 22.8
1950 ≤ P < 2250		44 19.1 26.5 3.7	158 68.7 18.3 13.2	28 12.2 17.1 2.3	230 19.3
2250 ≤ P < 2750		39 15.6 23.5 3.3	172 68.8 19.9 14.4	39 15.6 23.8 3.3	250 21.0
2750 ≤ P		15 8.0 9.0 1.3	157 83.5 18.2 13.2	16 8.5 9.8 1.3	188 15.8
COLUMN TOTAL		166 13.9	863 72.3	164 13.7	1193 100.0

Chi square = 28.94434 with 8 degrees of freedom; Significance = 0.0003

Lambda (asymmetric) = 0.00000 with CENS dependent

Uncertainty coefficient (asymmetric) = 0.01638 with CENS dependent

CENS = Census tract

Table A4. Cross tabulation of building surface area by building material for Revere.

Surface area (sq ft)		MAT 1.00	2.00	3.00	4.00	5.00	7.00	ROW TOTAL
P < 1250	COUNT	248	3	1	0	0	0	252
	ROW PCT	98.4	1.2	0.4	0.0	0.0	0.0	21.2
	COL PCT	22.3	6.0	5.6	0.0	0.0	0.0	
	TOT PCT	20.9	0.3	0.1	0.0	0.0	0.0	
1250 ≤ P < 1950	COUNT	259	9	0	0	0	0	268
	ROW PCT	96.6	3.4	0.0	0.0	0.0	0.0	22.5
	COL PCT	23.3	18.0	0.0	0.0	0.0	0.0	
	TOT PCT	21.8	0.8	0.0	0.0	0.0	0.0	
1950 ≤ P < 2250	COUNT	223	4	0	1	0	0	228
	ROW PCT	97.8	1.8	0.0	0.4	0.0	0.0	19.2
	COL PCT	20.0	8.0	0.0	20.0	0.0	0.0	
	TOT PCT	18.8	0.3	0.0	0.1	0.0	0.0	
2250 ≤ P < 2750	COUNT	240	6	1	0	0	0	247
	ROW PCT	97.2	2.4	0.4	0.0	0.0	0.0	20.8
	COL PCT	21.6	12.0	5.6	0.0	0.0	0.0	
	TOT PCT	20.2	0.5	0.1	0.0	0.0	0.0	
2750 ≤ P	COUNT	143	28	16	4	2	1	194
	ROW PCT	73.7	14.4	8.2	2.1	1.0	0.5	16.3
	COL PCT	12.8	56.0	88.9	80.0	100.0	100.0	
	TOT PCT	12.0	2.4	1.3	0.3	0.2	0.1	
COLUMN TOTAL		1113	50	18	5	2	1	1189
		93.6	4.2	1.5	0.4	0.2	0.1	100.0

Chi square = 169.86224 with 20 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.00000 with MAT dependent

Uncertainty coefficient (asymmetric) = 0.17901 with MAT dependent

Pearson's R = 0.24372; Significance = 0.0000

Building material (MAT) key: 1 = wood, 2 = brick, 3 = stucco, 4 = cement/concrete, 5 = metal, 7 = stone

Table A5. Cross tabulation of material by building type for Revere.

Material	COUNT ROW PCT COL PCT TOT PCT	TYPE 1.00	2.00	3.00	ROW TOTAL
1 = Wood		821 73.8 94.9 69.0	275 24.7 95.2 23.1	17 1.5 48.6 1.4	1113 93.6
2 = Brick		35 70.0 4.0 2.9	9 18.0 3.1 0.8	6 12.0 17.1 0.5	50 4.2
3 = Stucco		7 38.9 0.8 0.6	4 22.2 1.4 0.3	7 38.9 20.0 0.6	18 1.5
4 = Cement/concrete		2 40.0 0.2 0.2	1 20.0 0.3 0.1	2 40.0 5.7 0.2	5 0.4
5 = Metal		0 0.0 0.0 0.0	0 0.0 0.0 0.0	2 100.0 5.7 0.2	2 0.2
7 = Stone		0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 100.0 2.9 0.1	1 0.1
	COLUMN TOTAL	865 72.8	289 24.3	35 2.9	1189 100.0

Chi square = 227.50693 with 10 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.00926 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.04562 with TYPE dependent

Pearson's R = 0.24365; Significance = 0.0000

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A6. Cross tabulation of material by land use for Revere.

Material	COUNT / ROW PCT / COL PCT / TOT PCT	LU 11.00	12.00	17.00	51.00	62.00	ROW TOTAL
1 = Wood	COUNT	144	79	1	176	694	1094
	ROW PCT	13.2	7.2	0.1	16.1	63.4	94.1
	COL PCT	90.0	100.0	100.0	88.9	95.9	
	TOT PCT	12.4	6.8	0.1	15.1	59.7	
2 = Brick	COUNT	13	0	0	14	20	47
	ROW PCT	27.7	0.0	0.0	29.8	42.6	4.0
	COL PCT	8.1	0.0	0.0	7.1	2.8	
	TOT PCT	1.1	0.0	0.0	1.2	1.7	
3 = Stucco	COUNT	3	0	0	6	6	15
	ROW PCT	20.0	0.0	0.0	40.0	40.0	1.3
	COL PCT	1.9	0.0	0.0	3.0	0.8	
	TOT PCT	0.3	0.0	0.0	0.5	0.5	
4 = Cement/concrete	COUNT	0	0	0	2	1	3
	ROW PCT	0.0	0.0	0.0	66.7	33.3	0.3
	COL PCT	0.0	0.0	0.0	1.0	0.1	
	TOT PCT	0.0	0.0	0.0	0.2	0.1	
5 = Metal	COUNT	0	0	0	0	2	2
	ROW PCT	0.0	0.0	0.0	0.0	100.0	0.2
	COL PCT	0.0	0.0	0.0	0.0	0.3	
	TOT PCT	0.0	0.0	0.0	0.0	0.2	
7 = Stone	COUNT	0	0	0	0	1	1
	ROW PCT	0.0	0.0	0.0	0.0	100.0	0.1
	COL PCT	0.0	0.0	0.0	0.0	0.1	
	TOT PCT	0.0	0.0	0.0	0.0	0.1	
COLUMN TOTAL		160	79	1	198	724	1162
		13.8	6.8	0.1	17.0	62.3	100.0

Chi square = 33.10567 with 20 degrees of freedom; Significance = 0.0329

Lambda (asymmetric) = 0.00228 with LU dependent

Uncertainty coefficient (asymmetric) = 0.01388 with LU dependent

Pearson's R = -0.00925; Significance = 0.3764

Land use (LU) key:
- 11 = Residential
- 12 = Commercial and services
- 17 = Other urban or built-up land
- 51 = Streams and canals
- 62 = Non-forested wetlands

Table A7. Cross tabulation of material by census tract for Revere.

Material	COUNT / ROW PCT / COL PCT / TOT PCT	CENS 1704.00	CENS 1705.00	CENS 1706.00	ROW TOTAL
1 = Wood	COUNT	163	767	164	1094
	ROW PCT	14.9	70.1	15.0	94.1
	COL PCT	98.8	92.1	100.0	
	TOT PCT	14.0	66.0	14.1	
2 = Brick	COUNT	2	45	0	47
	ROW PCT	4.3	95.7	0.0	4.0
	COL PCT	1.2	5.4	0.0	
	TOT PCT	0.2	3.9	0.0	
3 = Stucco	COUNT	0	15	0	15
	ROW PCT	0.0	100.0	0.0	1.3
	COL PCT	0.0	1.8	0.0	
	TOT PCT	0.0	1.3	0.0	
4 = Cement/concrete	COUNT	0	3	0	3
	ROW PCT	0.0	100.0	0.0	0.3
	COL PCT	0.0	0.4	0.0	
	TOT PCT	0.0	0.3	0.0	
5 = Metal	COUNT	0	2	0	2
	ROW PCT	0.0	100.0	0.0	0.2
	COL PCT	0.0	0.2	0.0	
	TOT PCT	0.0	0.2	0.0	
7 = Stone	COUNT	0	1	0	1
	ROW PCT	0.0	100.0	0.0	0.1
	COL PCT	0.0	0.1	0.0	
	TOT PCT	0.0	0.1	0.0	
COLUMN TOTAL		165	833	164	1162
		14.2	71.7	14.1	100.0

Chi square = 23.34875 with 10 degrees of freedom; Significance = 0.0095

Lambda (asymmetric) = 0.00000 with CENS dependent

Uncertainty coefficient (asymmetric) = 0.01985 with CENS dependent

Table A8. Cross tabulation of building surface area by building type for Quincy.

Surface area (sq ft)	COUNT / ROW PCT / COL PCT / TOT PCT	TYPE 1.00	2.00	3.00	ROW TOTAL
P < 1330		53 86.9 28.0 17.8	2 3.3 4.9 0.7	6 9.8 9.0 2.0	61 20.5
1330 ≤ P < 1700		52 91.2 27.5 17.5	1 1.8 2.4 0.3	4 7.0 6.0 1.3	57 19.2
1700 ≤ P < 2400		48 77.4 25.4 16.2	10 16.1 24.4 3.4	4 6.5 6.0 1.3	62 20.9
2400 ≤ P < 60000		11 19.3 5.8 3.7	14 24.6 34.1 4.7	32 56.1 47.8 10.8	57 19.2
60000 ≤ P		25 41.7 13.2 8.4	14 23.3 34.1 4.7	21 35.0 31.3 7.1	60 20.2
	COLUMN TOTAL	189 63.6	41 13.8	67 22.6	297 100.0

Chi square = 106.08981 with 8 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.19444 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.21288 with TYPE dependent

Pearson's R = 0.43941; Significance = 0.0000

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A9. Cross tabulation of building surface area by land use for Quincy.

Surface area (sq ft) by LU (COUNT / ROW PCT / COL PCT / TOT PCT)

Surface area (sq ft)	11.00	12.00	13.00	ROW TOTAL
P < 1330	59 96.7 26.3 20.0	2 3.3 3.0 0.7	0 0.0 0.0 0.0	61 20.7
1330 ≤ P < 1700	55 96.5 24.6 18.6	2 3.5 3.0 0.7	0 0.0 0.0 0.0	57 19.3
1700 ≤ P < 2400	55 88.7 24.6 18.6	7 11.3 10.4 2.4	0 0.0 0.0 0.0	62 21.0
2400 ≤ P < 60000	26 46.4 11.6 8.8	27 48.2 40.3 9.2	3 5.4 75.0 1.0	56 19.0
60000 ≤ P	29 49.2 12.9 9.8	29 49.2 43.3 9.8	1 1.7 25.0 0.3	59 20.0
COLUMN TOTAL	224 75.9	67 22.7	4 1.4	295 100.0

Chi square = 86.22865 with 8 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.01408 with LU dependent

Uncertainty coefficient (asymmetric) = 0.25348 with LU dependent

Pearson's R = 0.46365; Significance = 0.0000

Land use (LU) key: 11 = Residential
12 = Commercial and services
13 = Industrial

Table A10. Cross tabulation of building surface area by census tract for Quincy.

Surface area (sq ft)

Surface area (sq ft)	CENS: COUNT / ROW PCT / COL PCT / TOT PCT	4177.00	4179.00	4180.00	4191.00	ROW TOTAL
P < 1330	COUNT	2	0	19	39	60
	ROW PCT	3.3	0.0	31.7	65.0	20.5
	COL PCT	3.8	0.0	18.4	29.1	
	TOT PCT	0.7	0.0	6.5	13.4	
1330 ≤ P < 1700	COUNT	1	0	3	52	56
	ROW PCT	1.8	0.0	5.4	92.9	19.2
	COL PCT	1.9	0.0	2.9	38.8	
	TOT PCT	0.3	0.0	1.0	17.8	
1700 ≤ P < 2400	COUNT	7	0	21	34	62
	ROW PCT	11.3	0.0	33.9	54.8	21.2
	COL PCT	13.5	0.0	20.4	25.4	
	TOT PCT	2.4	0.0	7.2	11.6	
2400 ≤ P < 60000	COUNT	19	3	31	2	55
	ROW PCT	34.5	5.5	56.4	3.6	18.8
	COL PCT	36.5	100.0	30.1	1.5	
	TOT PCT	6.5	1.0	10.6	0.7	
60000 ≤ P	COUNT	23	0	29	7	59
	ROW PCT	39.0	0.0	49.2	11.9	20.2
	COL PCT	44.2	0.0	28.2	5.2	
	TOT PCT	7.9	0.0	9.9	2.4	
COLUMN TOTAL		52	3	103	134	292
		17.8	1.0	35.3	45.9	100.0

Chi square = 146.72485 with 12 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.32278 with CENS dependent

Uncertainty coefficient (asymmetric) = 0.26690 with CENS dependent

Pearson's R = -0.59848; Significance = 0.0000

CENS = Census tract

Table A11. Cross tabulation of building surface area by material type for Quincy.

Surface area (sq ft)	MAT: COUNT / ROW PCT / COL PCT / TOT PCT	1.00	2.00	4.00	5.00	6.00	7.00	ROW TOTAL
P < 1330	COUNT	56	3	2	0	0	0	61
	ROW PCT	91.8	4.9	3.3	0.0	0.0	0.0	20.5
	COL PCT	24.6	6.8	11.1	0.0	0.0	0.0	
	TOT PCT	18.9	1.0	0.7	0.0	0.0	0.0	
1330 ≤ P < 1700	COUNT	52	2	3	0	0	0	57
	ROW PCT	91.2	3.5	5.3	0.0	0.0	0.0	19.2
	COL PCT	22.8	4.5	16.7	0.0	0.0	0.0	
	TOT PCT	17.5	0.7	1.0	0.0	0.0	0.0	
1700 ≤ P < 2400	COUNT	57	3	1	1	0	0	62
	ROW PCT	91.9	4.8	1.6	1.6	0.0	0.0	20.9
	COL PCT	25.0	6.8	5.6	25.0	0.0	0.0	
	TOT PCT	19.2	1.0	0.3	0.3	0.0	0.0	
2400 ≤ P < 60000	COUNT	22	24	7	1	2	1	57
	ROW PCT	38.6	42.1	12.3	1.8	3.5	1.8	19.2
	COL PCT	9.6	54.5	38.9	25.0	100.0	100.0	
	TOT PCT	7.4	8.1	2.4	0.3	0.7	0.3	
60000 ≤ P	COUNT	41	12	5	2	0	0	60
	ROW PCT	68.3	20.0	8.3	3.3	0.0	0.0	20.2
	COL PCT	18.0	27.3	27.8	50.0	0.0	0.0	
	TOT PCT	13.8	4.0	1.7	0.7	0.0	0.0	
COLUMN TOTAL		228	44	18	4	2	1	297
		76.8	14.8	6.1	1.3	0.7	0.3	100.0

Chi square = 82.53572 with 20 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.02899 with MAT dependent

Uncertainty coefficient (asymmetric) = 0.17244 with MAT dependent

Pearson's R = 0.25271; Significance = 0.0000

Building material (MAT) key:

1 = Wood
2 = Brick
3 = Stucco
4 = Cement/concrete
5 = Metal
6 = Shingles
7 = Stone

Table A12. Cross tabulation of material by building type for Quincy.

Material	COUNT / ROW PCT / COL PCT / TOT PCT	TYPE 1.00	TYPE 2.00	TYPE 3.00	ROW TOTAL
1 = Wood	COUNT	187	33	8	228
	ROW PCT	82.0	14.5	3.5	76.8
	COL PCT	98.9	80.5	11.9	
	TOT PCT	63.0	11.1	2.7	
2 = Brick	COUNT	0	6	38	44
	ROW PCT	0.0	13.6	86.4	14.8
	COL PCT	0.0	14.6	56.7	
	TOT PCT	0.0	2.0	12.8	
4 = Cement/concrete	COUNT	0	1	17	18
	ROW PCT	0.0	5.6	94.4	6.1
	COL PCT	0.0	2.4	25.4	
	TOT PCT	0.0	0.3	5.7	
5 = Metal	COUNT	0	1	3	4
	ROW PCT	0.0	25.0	75.0	1.3
	COL PCT	0.0	2.4	4.5	
	TOT PCT	0.0	0.3	1.0	
6 = Shingles	COUNT	2	0	0	2
	ROW PCT	100.0	0.0	0.0	0.7
	COL PCT	1.1	0.0	0.0	
	TOT PCT	0.7	0.0	0.0	
7 = Stone	COUNT	0	0	1	1
	ROW PCT	0.0	0.0	100.0	0.3
	COL PCT	0.0	0.0	1.5	
	TOT PCT	0.0	0.0	0.3	
COLUMN TOTAL		189	41	67	297
		63.6	13.8	22.6	100.0

Chi square = 222.19681 with 10 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.54630 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.43205 with TYPE dependent

Pearson's R = 0.60608; Significance = 0.0000

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A13. Cross tabulation of material by land use for Quincy.

Material	COUNT / ROW PCT / COL PCT / TOT PCT	LU 11.00	LU 12.00	LU 13.00	ROW TOTAL
1 = Wood	COUNT	197	30	1	228
	ROW PCT	86.4	13.2	0.4	77.3
	COL PCT	87.9	44.8	25.0	
	TOT PCT	66.8	10.2	0.3	
2 = Brick	COUNT	14	28	1	43
	ROW PCT	32.6	65.1	2.3	14.6
	COL PCT	6.3	41.8	25.0	
	TOT PCT	4.7	9.5	0.3	
4 = Cement/concrete	COUNT	7	9	1	17
	ROW PCT	41.2	52.9	5.9	5.8
	COL PCT	3.1	13.4	25.0	
	TOT PCT	2.4	3.1	0.3	
5 = Metal	COUNT	4	0	0	4
	ROW PCT	100.0	0.0	0.0	1.4
	COL PCT	1.8	0.0	0.0	
	TOT PCT	1.4	0.0	0.0	
6 = Shingles	COUNT	1	0	1	2
	ROW PCT	50.0	0.0	50.0	0.7
	COL PCT	0.4	0.0	25.0	
	TOT PCT	0.3	0.0	0.3	
7 = Stone	COUNT	1	0	0	1
	ROW PCT	100.0	0.0	0.0	0.3
	COL PCT	0.4	0.0	0.0	
	TOT PCT	0.3	0.0	0.0	
COLUMN TOTAL		224	67	4	295
		75.9	22.7	1.4	100.0

Chi square = 108.09769 with 10 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.22535 with LU dependent

Uncertainty coefficient (asymmetric) = 0.19916 with LU dependent

Pearson's R = 0.29973; Significance = 0.0000

Land use (LU) key: 11 = Residential
12 = Commercial and services
13 = Industrial

Table A14. Cross tabulation of material by census tract for Quincy.

Material	CENS: COUNT / ROW PCT / COL PCT / TOT PCT	4177.00	4179.00	4180.00	4191.00	ROW TOTAL
1 = Wood	COUNT	26	0	69	133	228
	ROW PCT	11.4	0.0	30.3	58.3	78.1
	COL PCT	50.0	0.0	67.0	99.3	
	TOT PCT	8.9	0.0	23.6	45.5	
2 = Brick	COUNT	23	3	13	1	40
	ROW PCT	57.5	7.5	32.5	2.5	13.7
	COL PCT	44.2	100.0	12.6	0.7	
	TOT PCT	7.9	1.0	4.5	0.3	
4 = Cement/concrete	COUNT	3	0	14	0	17
	ROW PCT	17.6	0.0	82.4	0.0	5.8
	COL PCT	5.8	0.0	13.6	0.0	
	TOT PCT	1.0	0.0	4.8	0.0	
5 = Metal	COUNT	0	0	4	0	4
	ROW PCT	0.0	0.0	100.0	0.0	1.4
	COL PCT	0.0	0.0	3.9	0.0	
	TOT PCT	0.0	0.0	1.4	0.0	
6 = Shingles	COUNT	0	0	2	0	2
	ROW PCT	0.0	0.0	100.0	0.0	0.7
	COL PCT	0.0	0.0	1.9	0.0	
	TOT PCT	0.0	0.0	0.7	0.0	
7 = Stone	COUNT	0	0	1	0	1
	ROW PCT	0.0	0.0	100.0	0.0	0.3
	COL PCT	0.0	0.0	1.0	0.0	
	TOT PCT	0.0	0.0	0.3	0.0	
COLUMN TOTAL		52	3	103	134	292
		17.8	1.0	35.3	45.9	100.0

Chi square = 116.60788 with 15 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.27215 with CENS dependent

Uncertainty coefficient (asymmetric) = 0.18350 with CENS dependent

Pearson's R = -0.46424; Significance = 0.0000

CENS = Census tract

Table A15. Cross tabulation of building surface area by building type for Stamford.

Surface area (sq ft)	COUNT / ROW PCT / COL PCT / TOT PCT	TYPE 1.00	TYPE 2.00	TYPE 3.00	ROW TOTAL
P < 1600	COUNT	10	18	14	42
	ROW PCT	23.8	42.9	33.3	17.7
	COL PCT	45.5	12.2	20.9	
	TOT PCT	4.2	7.6	5.9	
1600 ≤ P < 1900	COUNT	2	15	2	19
	ROW PCT	10.5	78.9	10.5	8.0
	COL PCT	9.1	10.1	3.0	
	TOT PCT	0.8	6.3	0.8	
1900 ≤ P < 2200	COUNT	0	34	1	35
	ROW PCT	0.0	97.1	2.9	14.8
	COL PCT	0.0	23.0	1.5	
	TOT PCT	0.0	14.3	0.4	
2200 ≤ P < 4575	COUNT	2	55	13	70
	ROW PCT	2.9	78.6	18.6	29.5
	COL PCT	9.1	37.2	19.4	
	TOT PCT	0.8	23.2	5.5	
4575 ≤ P	COUNT	8	26	37	71
	ROW PCT	11.3	36.6	52.1	30.0
	COL PCT	36.4	17.6	55.2	
	TOT PCT	3.4	11.0	15.6	
COLUMN TOTAL		22	148	67	237
		9.3	62.4	28.3	100.0

Chi square = 63.99710 with 8 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.12360 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.16740 with TYPE dependent

Pearson's R = 0.20281; Significance = 0.0008

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A16. Cross tabulation of building surface area by land use for Stamford.

Surface area (sq ft) / COUNT / ROW PCT / COL PCT / TOT PCT	LU 11.00	LU 12.00	ROW TOTAL
P < 1600	66 98.5 21.2 18.9	1 1.5 2.6 0.3	67 19.1
1600 ≤ P < 1900	36 92.3 11.6 10.3	3 7.7 7.7 0.9	39 11.1
1900 ≤ P < 2200	99 92.5 31.8 28.3	8 7.5 20.5 2.3	107 30.6
2200 ≤ P < 4575	64 86.5 20.6 18.3	10 13.5 25.6 2.9	74 21.1
4575 ≤ P	46 73.0 14.8 13.1	17 27.0 43.6 4.9	63 18.0
COLUMN TOTAL	311 88.9	39 11.1	350 100.0

Chi square = 24.61073 with 4 degrees of freedom; Significance = 0.0001

Lambda (asymmetric) = 0.00000 with LU dependent

Uncertainty coefficient (asymmetric) = 0.09865 with LU dependent

Pearson's R = 0.24341; Significance = 0.0000

Land use (LU) key: 11 = Residential
12 = Commercial and services

Table A17. Cross tabulation of building surface area by census tract for Stamford.

Surface area (sq ft) — COUNT / ROW PCT / COL PCT / TOT PCT	CENS 201.00	213.00	215.00	216.00	ROW TOTAL
P < 1600	11 15.9 15.1 3.0	38 55.1 26.2 10.5	3 4.3 14.3 0.8	17 24.6 13.8 4.7	69 19.1
1600 ≤ P < 1900	1 2.6 1.4 0.3	27 69.2 18.6 7.5	1 2.6 4.8 0.3	10 25.6 8.1 2.8	39 10.8
1900 ≤ P < 2200	14 13.1 19.2 3.9	58 54.2 40.0 16.0	4 3.7 19.0 1.1	31 29.0 25.2 8.6	107 29.6
2200 ≤ P < 4575	17 22.4 23.3 4.7	7 9.2 4.8 1.9	9 11.8 42.9 2.5	43 56.6 35.0 11.9	76 21.0
4575 ≤ P	30 42.3 41.1 8.3	15 21.1 10.3 4.1	4 5.6 19.0 1.1	22 31.0 17.9 6.1	71 19.6
COLUMN TOTAL	73 20.2	145 40.1	21 5.8	123 34.0	362 100.0

Chi square = 90.04289 with 12 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.23502 with CENS dependent

Uncertainty coefficent (asymmetric) = 0.10705 with CENS dependent

Pearson's R = -0.16360; Significance = 0.0009

CENS = Census tract

Table A18. Cross tabulation of building surface area by material type for Stamford.

Surface area (sq ft)	COUNT / ROW PCT / COL PCT / TOT PCT	MAT 1.00	2.00	3.00	4.00	5.00	7.00	ROW TOTAL
P < 1600	COUNT	52	5	1	10	0	2	70
	ROW PCT	74.3	7.1	1.4	14.3	0.0	2.9	19.2
	COL PCT	18.9	12.5	16.7	27.0	0.0	50.0	
	TOT PCT	14.3	1.4	0.3	2.7	0.0	0.5	
1600 ≤ P < 1900	COUNT	37	0	0	2	0	0	39
	ROW PCT	94.9	0.0	0.0	5.1	0.0	0.0	10.7
	COL PCT	13.5	0.0	0.0	5.4	0.0	0.0	
	TOT PCT	10.2	0.0	0.0	0.5	0.0	0.0	
1900 ≤ P < 2200	COUNT	105	1	1	0	0	0	107
	ROW PCT	98.1	0.9	0.9	0.0	0.0	0.0	29.4
	COL PCT	38.2	2.5	16.7	0.0	0.0	0.0	
	TOT PCT	28.8	0.3	0.3	0.0	0.0	0.0	
2200 ≤ P < 4575	COUNT	58	10	4	4	0	0	76
	ROW PCT	76.3	13.2	5.3	5.3	0.0	0.0	20.9
	COL PCT	21.1	25.0	66.7	10.8	0.0	0.0	
	TOT PCT	15.9	2.7	1.1	1.1	0.0	0.0	
4575 ≤ P	COUNT	23	24	0	21	2	2	72
	ROW PCT	31.9	33.3	0.0	29.2	2.8	2.8	19.8
	COL PCT	8.4	60.0	0.0	56.8	100.0	50.0	
	TOT PCT	6.3	6.6	0.0	5.8	0.5	0.5	
COLUMN TOTAL		275	40	6	37	2	4	364
		75.5	11.0	1.6	10.2	0.5	1.1	100.0

Chi square = 138.36243 with 20 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.01124 with MAT dependent

Uncertainty coefficient (asymmetric) = 0.23783 with MAT dependent

Pearson's R = 0.20937; Significance = 0.0000

Building material (MAT) key:

- 1 = Wood
- 2 = Brick
- 3 = Stucco
- 4 = Cement/concrete
- 5 = Metal
- 7 = Stone

Table A19. Cross tabulation of material by building type for Stamford.

Material	COUNT / ROW PCT / COL PCT / TOT PCT	TYPE 1.00	2.00	3.00	ROW TOTAL
1 = Wood	COUNT	20	125	5	150
	ROW PCT	13.3	83.3	3.3	63.6
	COL PCT	90.9	84.5	7.6	
	TOT PCT	8.5	53.0	2.1	
2 = Brick	COUNT	1	15	22	38
	ROW PCT	2.6	39.5	57.9	16.1
	COL PCT	4.5	10.1	33.3	
	TOT PCT	0.4	6.4	9.3	
3 = Stucco	COUNT	1	5	0	6
	ROW PCT	16.7	83.3	0.0	2.5
	COL PCT	4.5	3.4	0.0	
	TOT PCT	0.4	2.1	0.0	
4 = Cement/concrete	COUNT	0	1	35	36
	ROW PCT	0.0	2.8	97.2	15.3
	COL PCT	0.0	0.7	53.0	
	TOT PCT	0.0	0.4	14.8	
5 = Metal	COUNT	0	0	2	2
	ROW PCT	0.0	0.0	100.0	0.8
	COL PCT	0.0	0.0	3.0	
	TOT PCT	0.0	0.0	0.8	
7 = Stone	COUNT	0	2	2	4
	ROW PCT	0.0	50.0	50.0	1.7
	COL PCT	0.0	1.4	3.0	
	TOT PCT	0.0	0.8	0.8	
COLUMN TOTAL		22	148	66	236
		9.3	62.7	28.0	100.0

Chi square = 157.04660 with 10 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.48864 with TYPE dependent

Uncertainty coefficient (asymmetric) = 0.41690 with TYPE dependent

Pearson's R = 0.60098; Significance = 0.0000

Building type (TYPE) key: 1 = Single-family residential
2 = Multi-family residential
3 = Industrial/commercial

Table A20. Cross tabulation of material by land use for Stamford.

Material

Material	COUNT / ROW PCT / COL PCT / TOT PCT	LU 11.00	LU 12.00	ROW TOTAL
1 = Wood	COUNT	260	15	275
	ROW PCT	94.5	5.5	78.8
	COL PCT	83.6	39.5	
	TOT PCT	74.5	4.3	
2 = Brick	COUNT	28	5	33
	ROW PCT	84.8	15.2	9.5
	COL PCT	9.0	13.2	
	TOT PCT	8.0	1.4	
3 = Stucco	COUNT	1	5	6
	ROW PCT	16.7	83.3	1.7
	COL PCT	0.3	13.2	
	TOT PCT	0.3	1.4	
4 = Cement/concrete	COUNT	19	10	29
	ROW PCT	65.5	34.5	8.3
	COL PCT	6.1	26.3	
	TOT PCT	5.4	2.9	
5 = Metal	COUNT	1	1	2
	ROW PCT	50.0	50.0	0.6
	COL PCT	0.3	2.6	
	TOT PCT	0.3	0.3	
7 = Stone	COUNT	2	2	4
	ROW PCT	50.0	50.0	1.1
	COL PCT	0.6	5.3	
	TOT PCT	0.6	0.6	
COLUMN TOTAL		311	38	349
		89.1	10.9	100.0

Chi square = 67.53949 with 5 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.10526 with LU dependent

Uncertainty coefficient (asymmetric) = 0.18584 with LU dependent

Pearson's R = 0.36309; Significance = 0.0000

Land use (LU) key: 11 = Residential
12 = Commercial and services

Table A21. Cross tabulation of material by census tract for Stamford.

Material	CENS COUNT ROW PCT COL PCT TOT PCT	201.00	213.00	215.00	216.00	ROW TOTAL
1 = Wood		20 7.3 27.8 5.5	131 47.6 90.3 36.3	13 4.7 61.9 3.6	111 40.4 90.2 30.7	275 76.2
2 = Brick		20 50.0 27.8 5.5	9 22.5 6.2 2.5	2 5.0 9.5 0.6	9 22.5 7.3 2.5	40 11.1
3 = Stucco		5 83.3 6.9 1.4	1 16.7 0.7 0.3	0 0.0 0.0 0.0	0 0.0 0.0 0.0	6 1.7
4 = Cement/concrete		22 64.7 30.6 6.1	4 11.8 2.8 1.1	6 17.6 28.6 1.7	2 5.9 1.6 0.6	34 9.4
5 = Metal		1 50.0 1.4 0.3	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 50.0 0.8 0.3	2 0.6
7 = Stone		4 100.0 5.6 1.1	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	4 1.1
	COLUMN TOTAL	72 19.9	145 40.2	21 5.8	123 34.1	361 100.0

Chi square = 142.96911 with 15 degrees of freedom; Significance = 0.0000

Lambda (asymmetric) = 0.17593 with CENS dependent

Uncertainty coefficient (asymmetric) = 0.14882 with CENS dependent

Pearson's R = -0.52048; Significance = 0.0000

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